Fiber-Based Electro-Optic Field-Mapping System

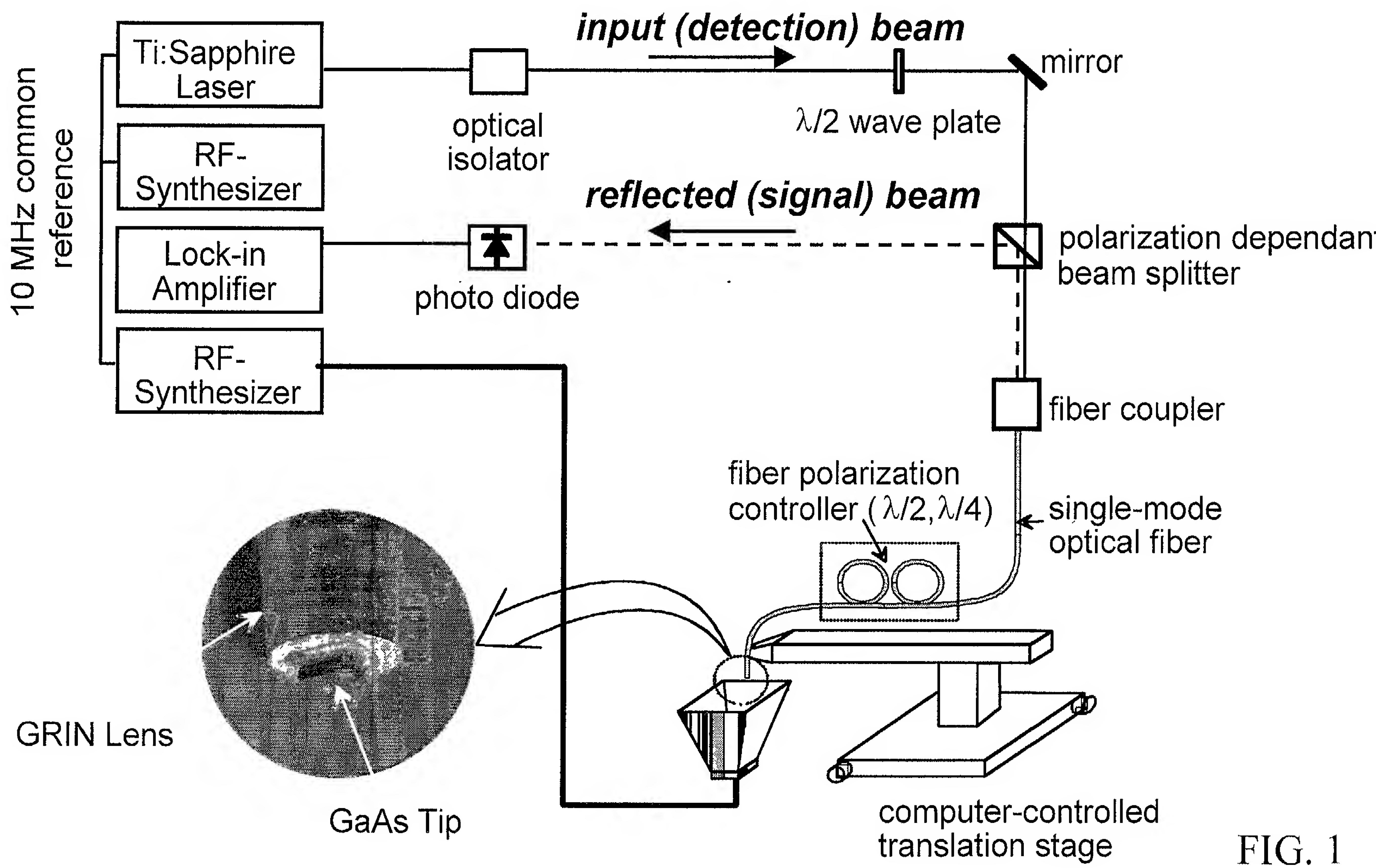


FIG. 1

Fiber-Based Electro-Optic Field-Mapping System
Polarization Control

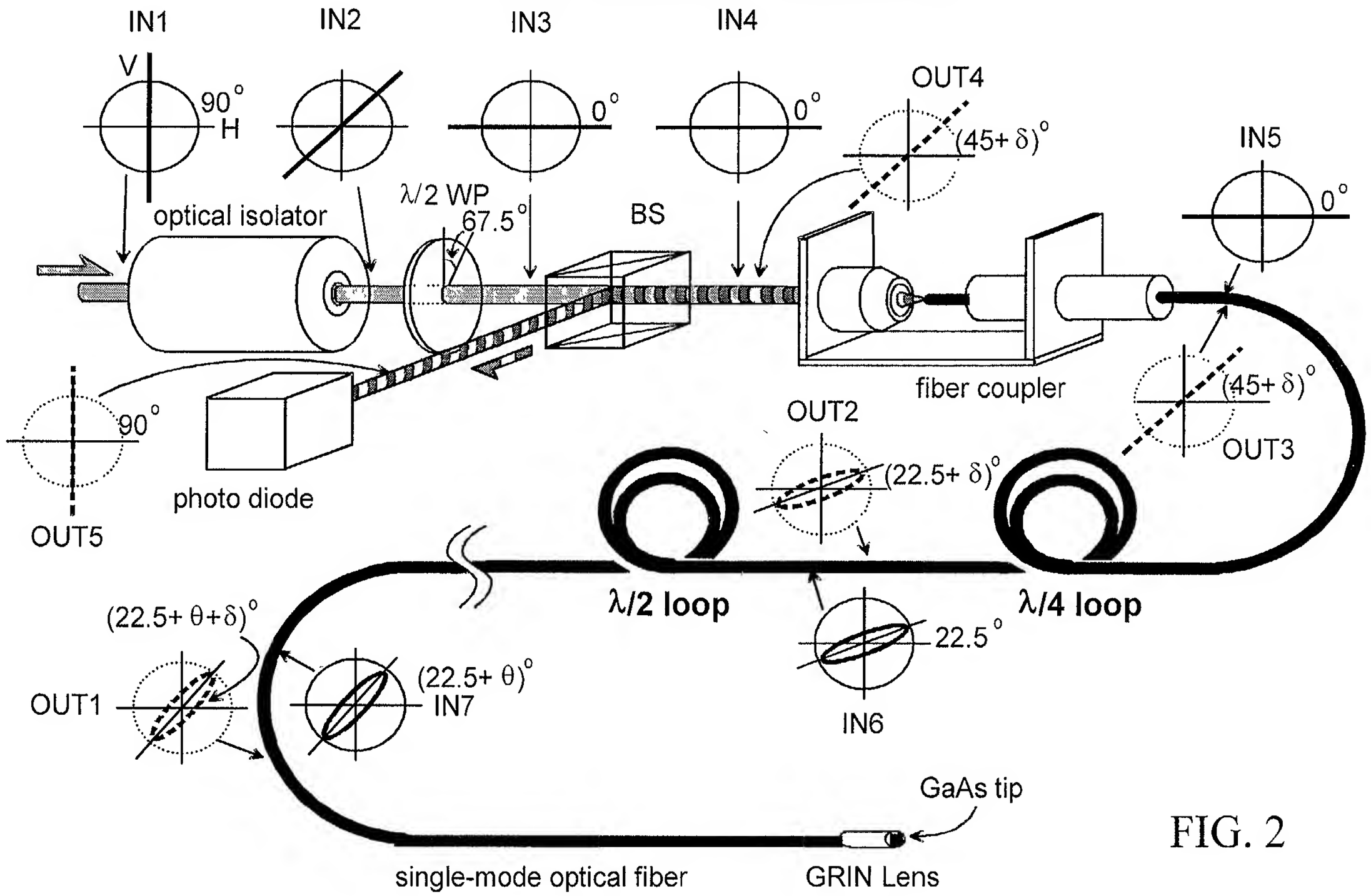


FIG. 2

V H detection (input) beam polarization (w.r.t. horizontal axis)

V H signal (reflected) beam (w.r.t. horizontal axis)

Fiber-Based Electro-Optic Sampling System
GRIN Lens

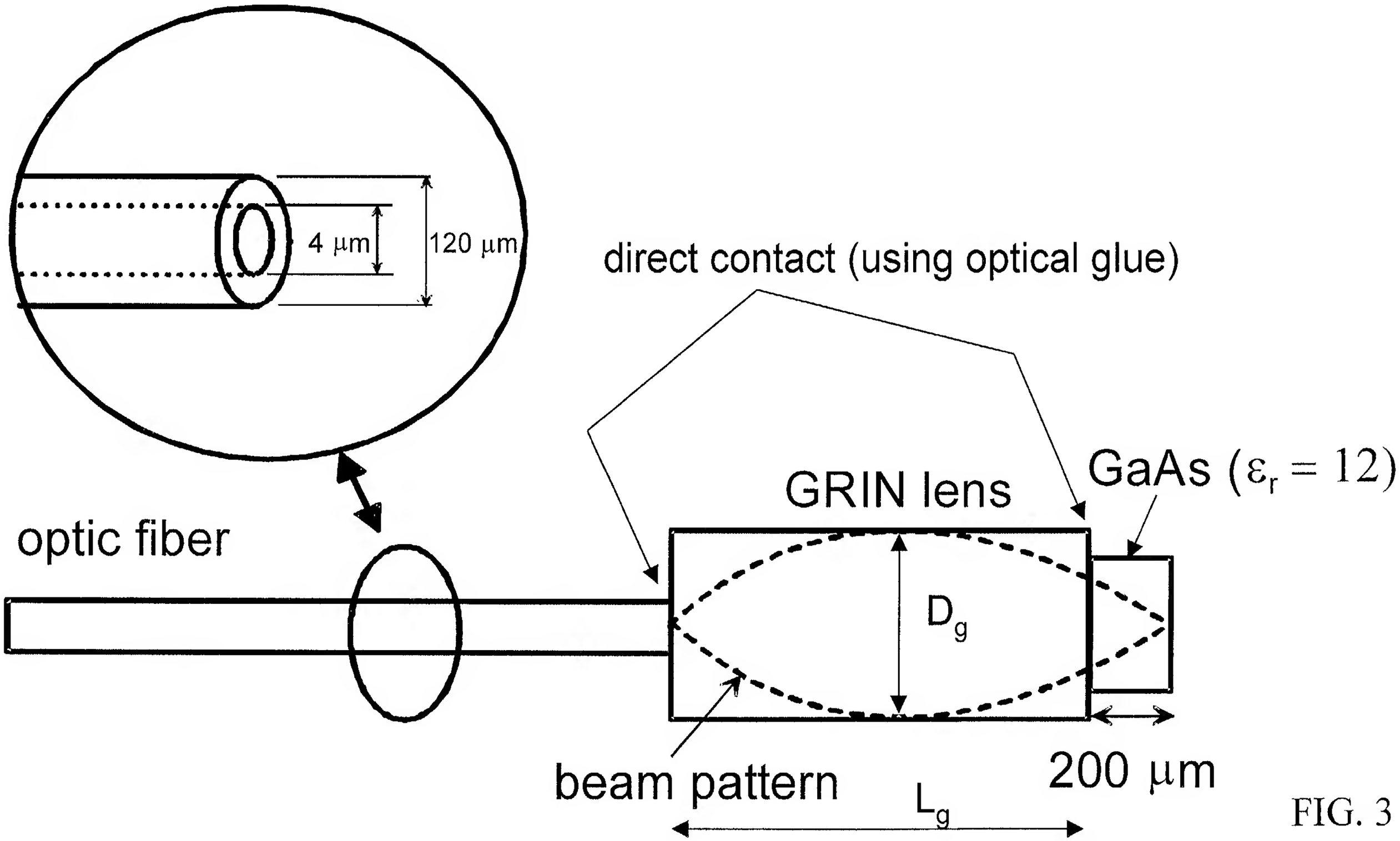
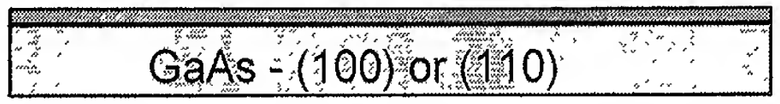


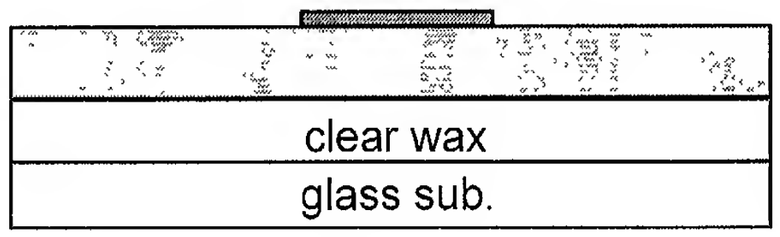
FIG. 3

Fiber-Based Electro-Optic Sampling System
Probe Tip Fabrication Procedure

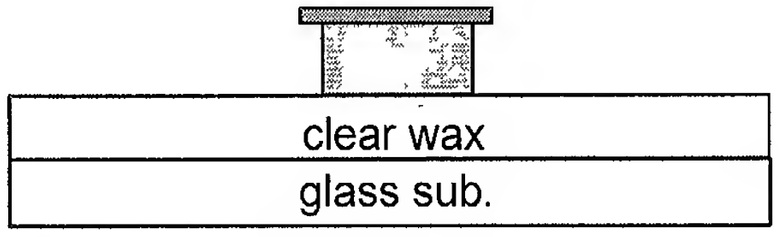


PR 1827 : 3.5 Krpm (30 sec), 105 C° (1 min)

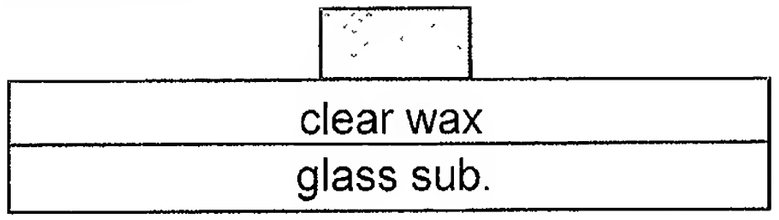
PR 1827 : expose (15 sec), develope (50 sec),
hard bake (105 C°, 1 min)



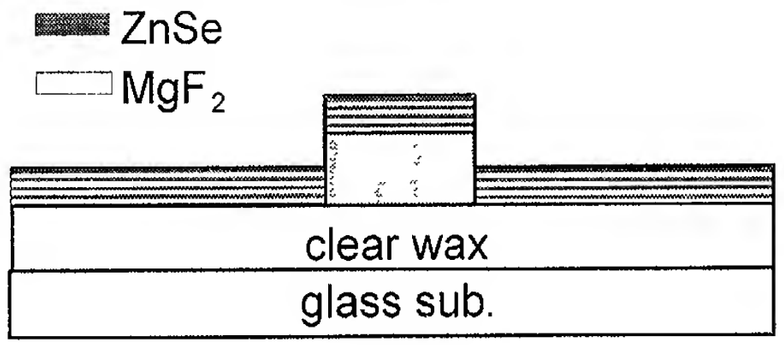
mount sample on glass substrate
using clear wax (on the 150 C° hot plate)



wet etching : $H_2SO_4 : H_2O_2 : H_2O$
= 1 : 8 : 1
+ few drops of NH_4OH
agitate 30 sec every 30 sec
change etchant every 10 min.

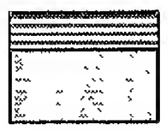


expose without mask (15 sec), develope (90 sec)



Distributed Bragg Reflector (DBR) deposition

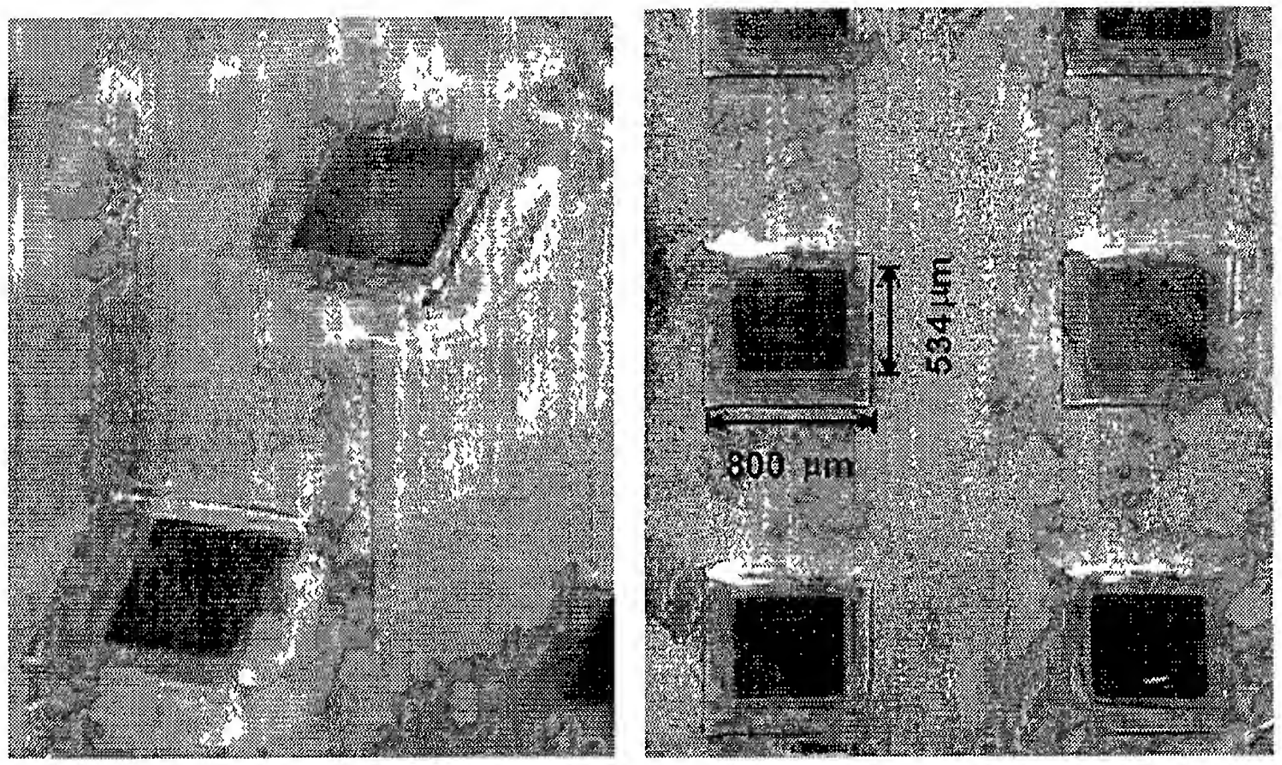
MgF_2 = 1,403 A°, ZnSe = 833 A° x 4 sets



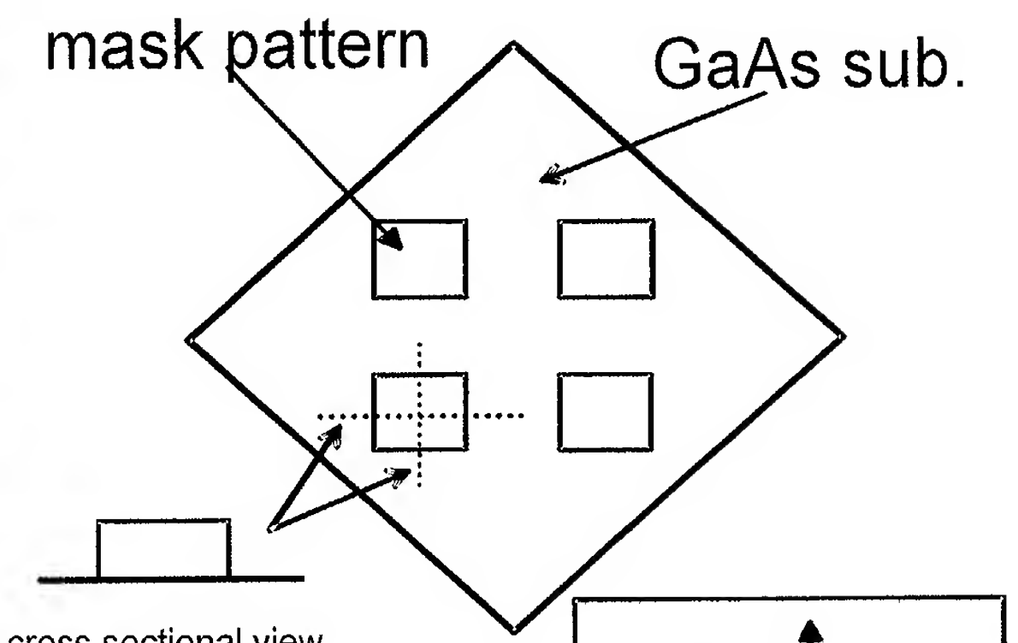
Final probe tip
(released in the hot aceton)

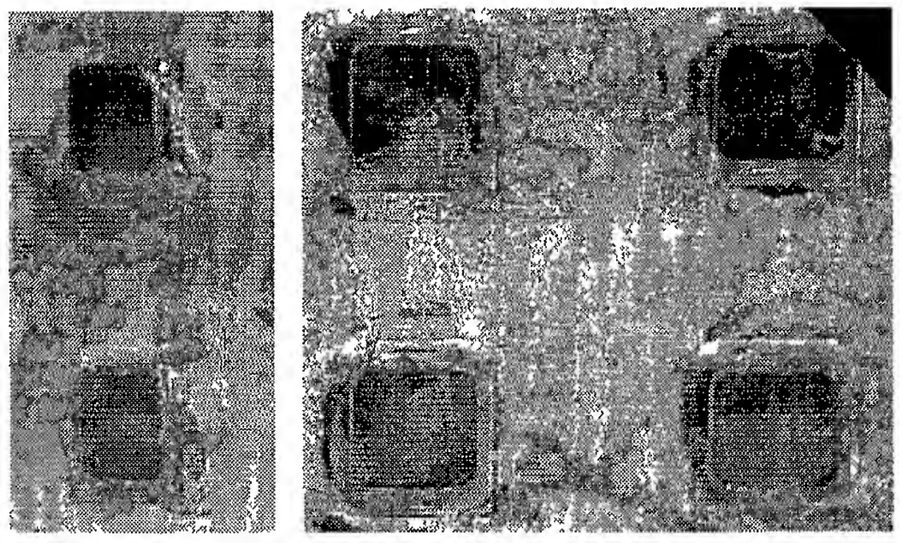
FIG. 4

Fiber-Based Electro-Optic Sampling System Probe Tip Fabrication - (100) GaAs



etching depth ~ 160 μm (7.95 μm/min x 20 min)
(lateral : 130~150 μm, 6.5~7.5 μm/min)





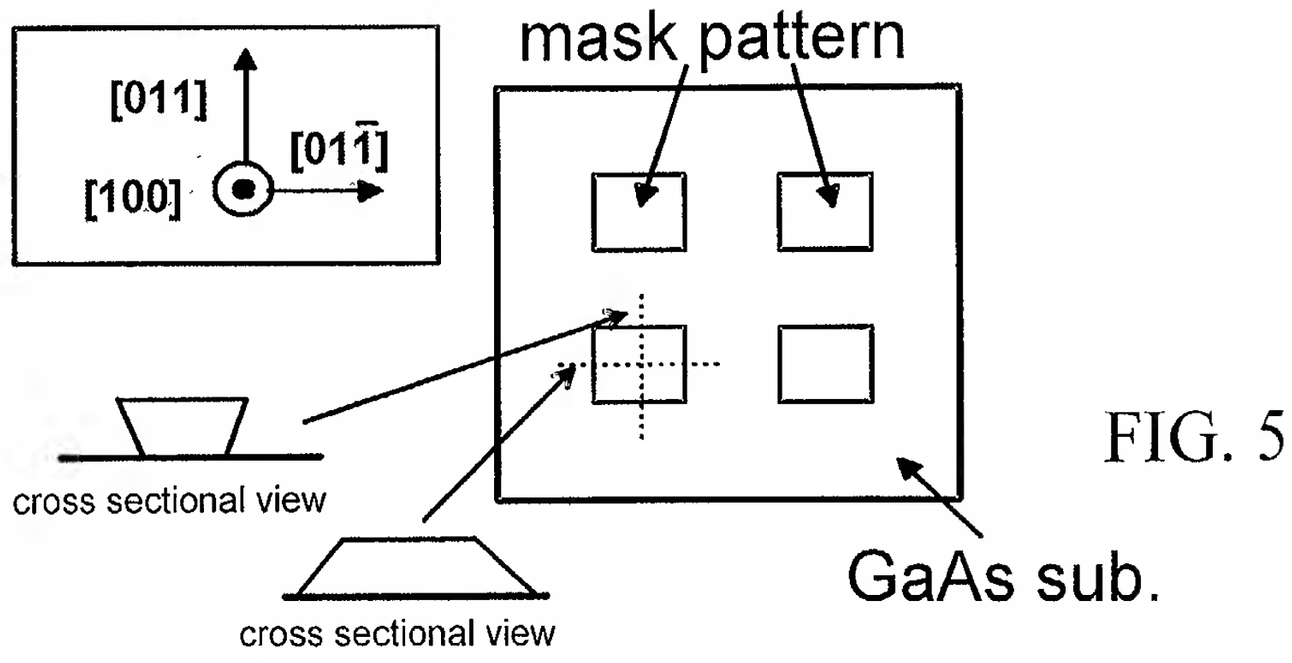


FIG. 5

Fiber-Based Electro-Optic Sampling System
Probe Tip Fabrication - (110) GaAs

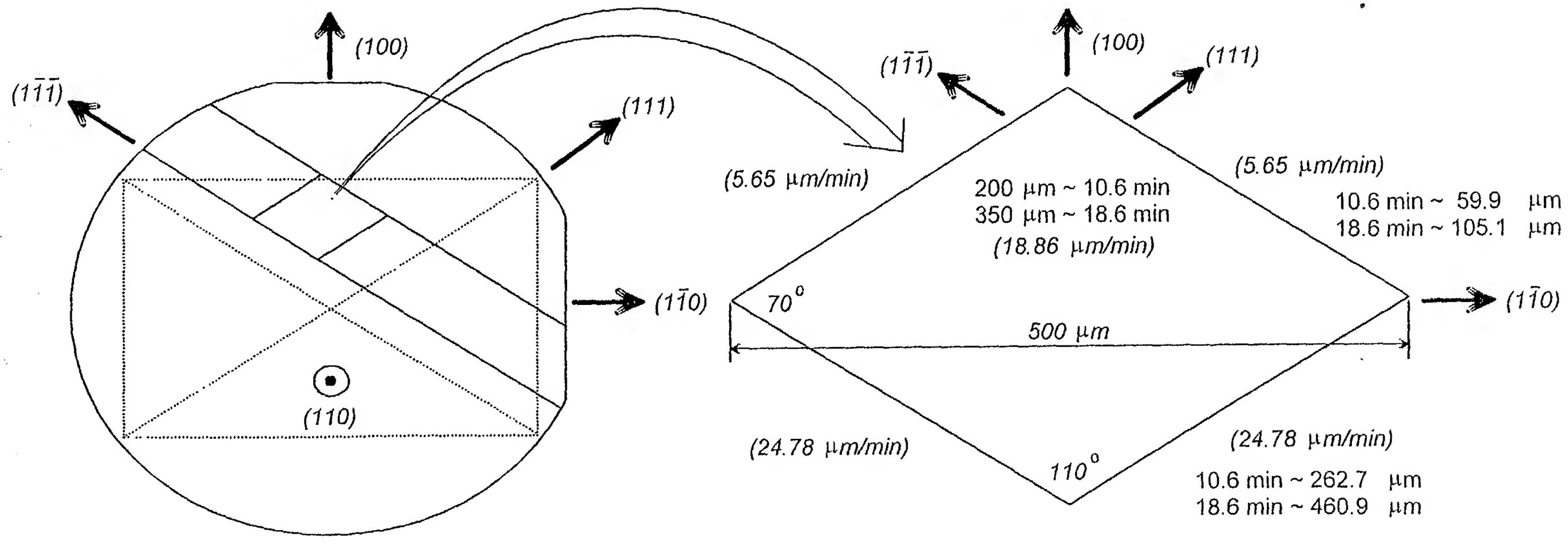
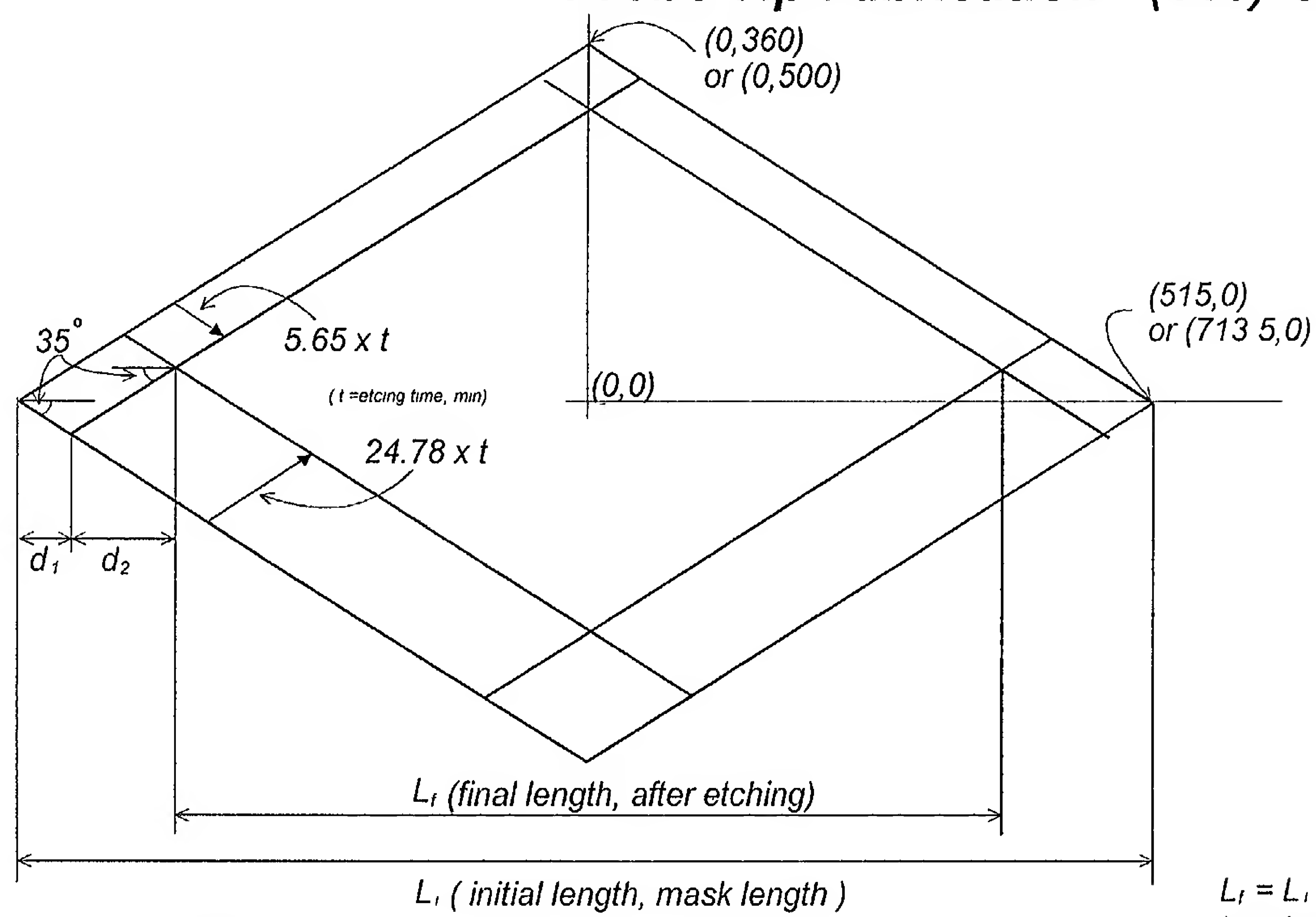


FIG. 6

Fiber-Based Electro-Optic Sampling System
Probe Tip Fabrication - (110) GaAs



goal : $L_f = 500$ µm

FIG. 7

$L_f = L_i - (d_1 + d_2) \times 2$
$L_f = L_i - [\,5.65 \times t \times \cos(35)^{\circ} + 24.78 \times t \times \sin(55)^{\circ}\,] \times 2 = 500$
$L_i = 500 + [\,5.65 \times \cos(35)^{\circ} + 24.78 \times \sin(55)^{\circ}\,] \times 2 \times t$

where,
$t = 200 / 18.86$ (µm/min) = 10.6 min for 200 µm wafer
$t = 350 / 18.86$ (µm/min) = 18.6 min for 350 µm wafer
(t = etching time, min)

$L_i = 1029$ µm for 200 µm wafer,
$= 1427$ µm for 350 µm wafer

Fiber-Based Electro-Optic Sampling System Probe Head Assembly

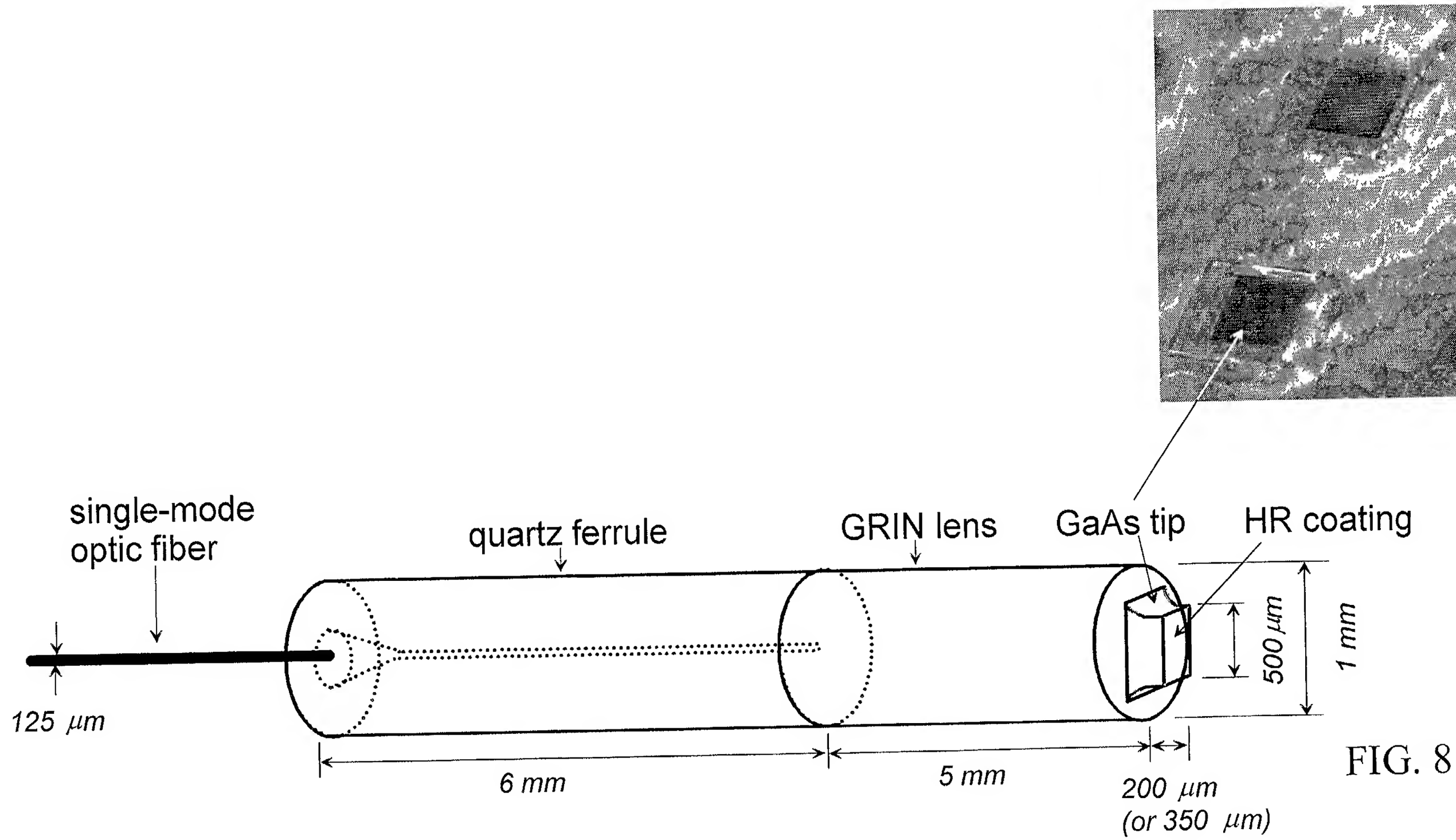


FIG. 8

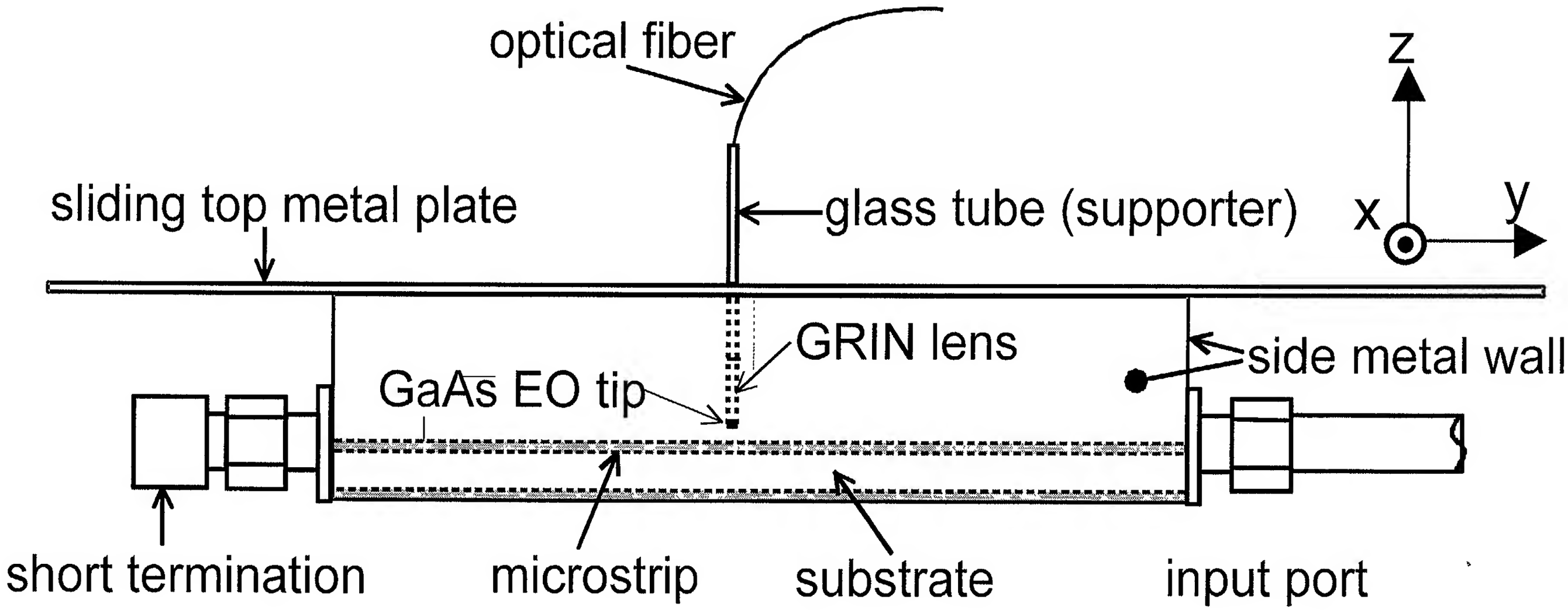

optical fiber
z
sliding top metal plate
glass tube (supporter)
x
y
GRIN lens
side metal wall
GaAs EO tip
short termination
microstrip
substrate
input port

FIG. 9

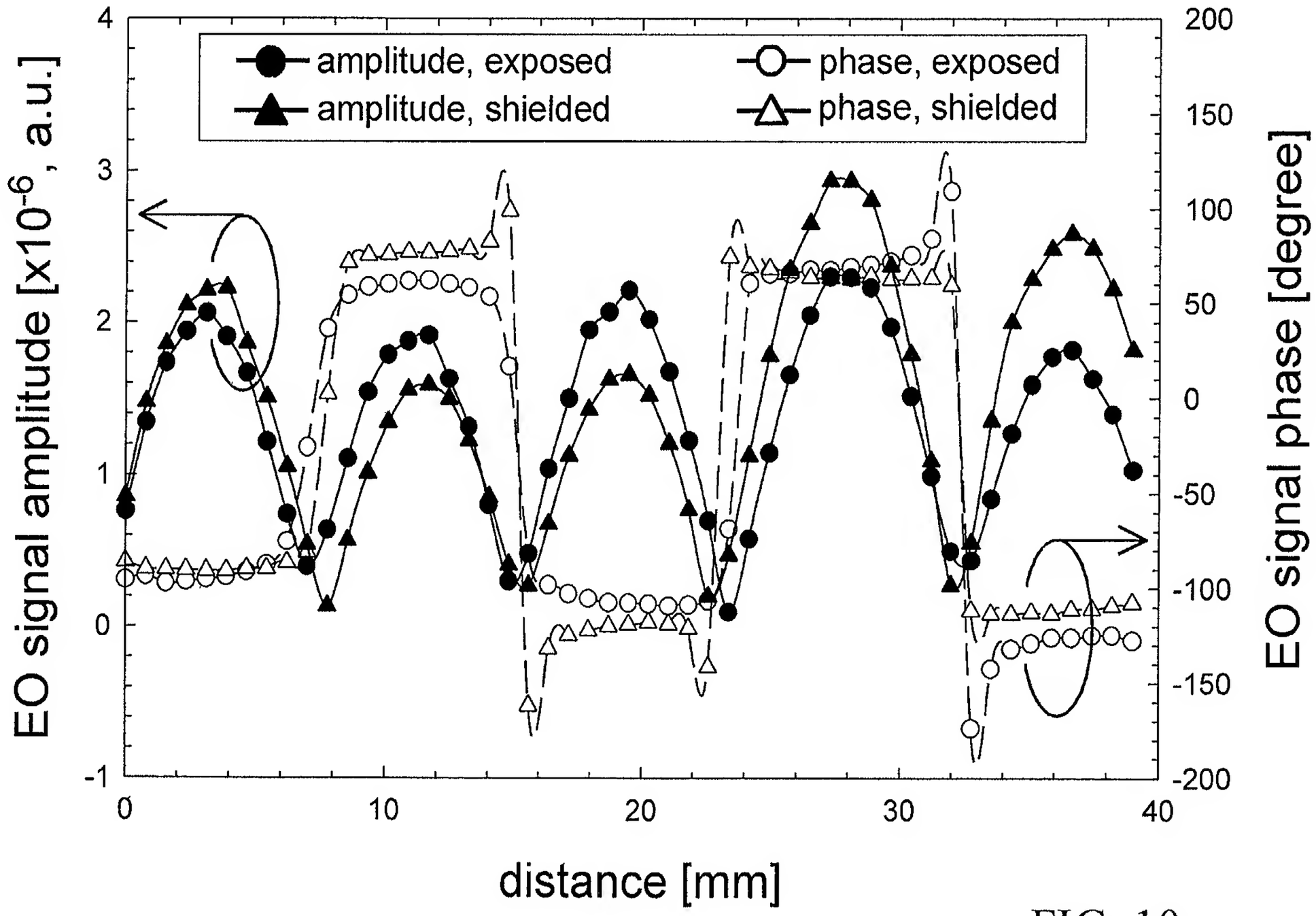

amplitude, exposed
amplitude, shielded
phase, exposed
phase, shielded
EO signal amplitude [x10-6, a.u.]
EO signal phase [degree]
distance [mm]
4
3
2
1
0
-1
200
150
100
50
0
-50
-100
-150
-200
0
10
20
30
40

FIG. 10

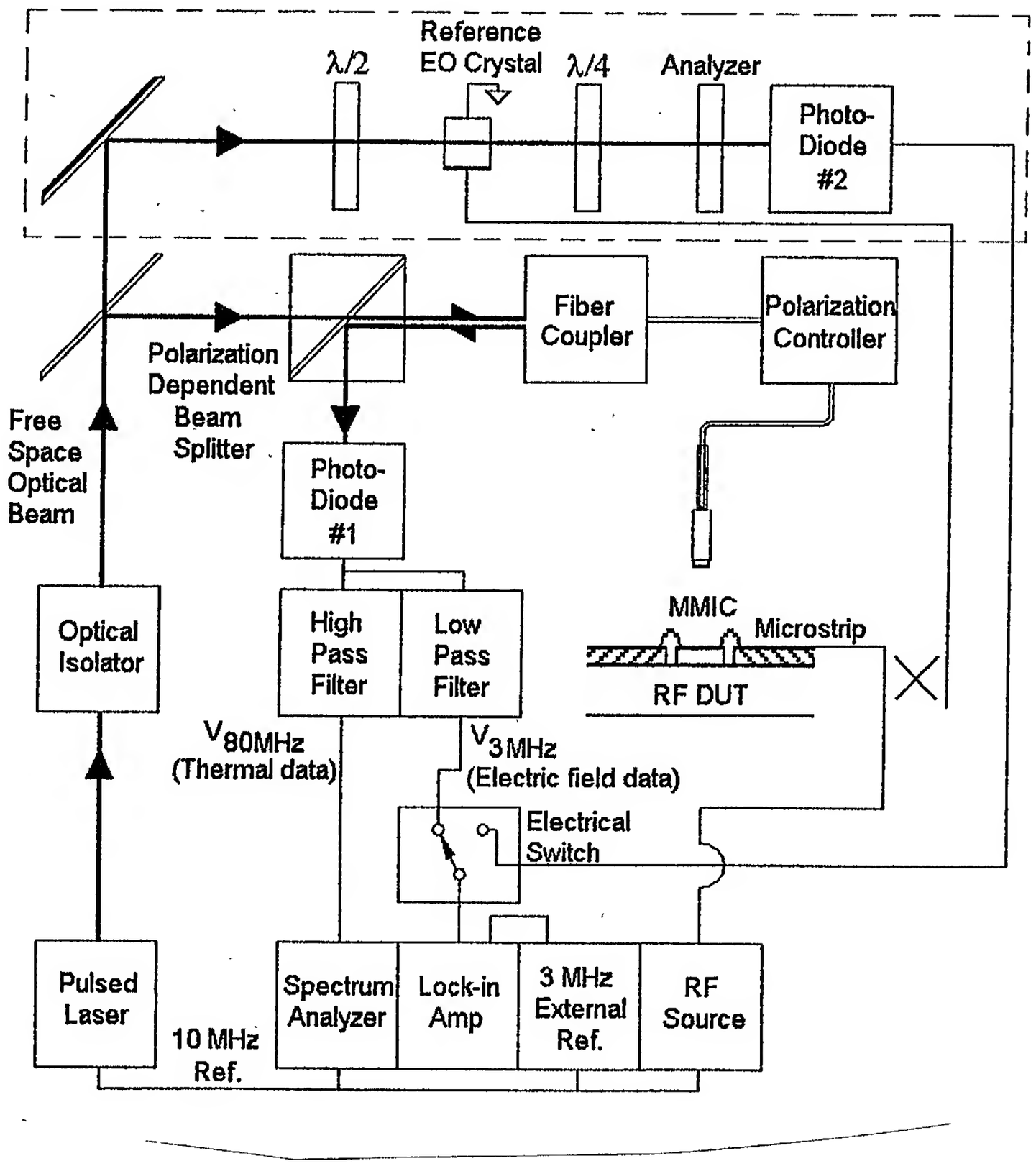

Reference
EO Crystal
λ/2
λ/4
Analyzer
Photo-
Diode
#2
Fiber
Coupler
Polarization
Controller
Polarization
Dependent
Beam
Splitter
Free
Space
Optical
Beam
Photo-
Diode
#1
Optical
Isolator
High
Pass
Filter
Low
Pass
Filter
MMIC
Microstrip
RF DUT
V80MHz
(Thermal data)
V3MHz
(Electric field data)
Electrical
Switch
Pulsed
Laser
10 MHz
Ref.
Spectrum
Analyzer
Lock-in
Amp
3 MHz
External
Ref.
RF
Source

Fig 11

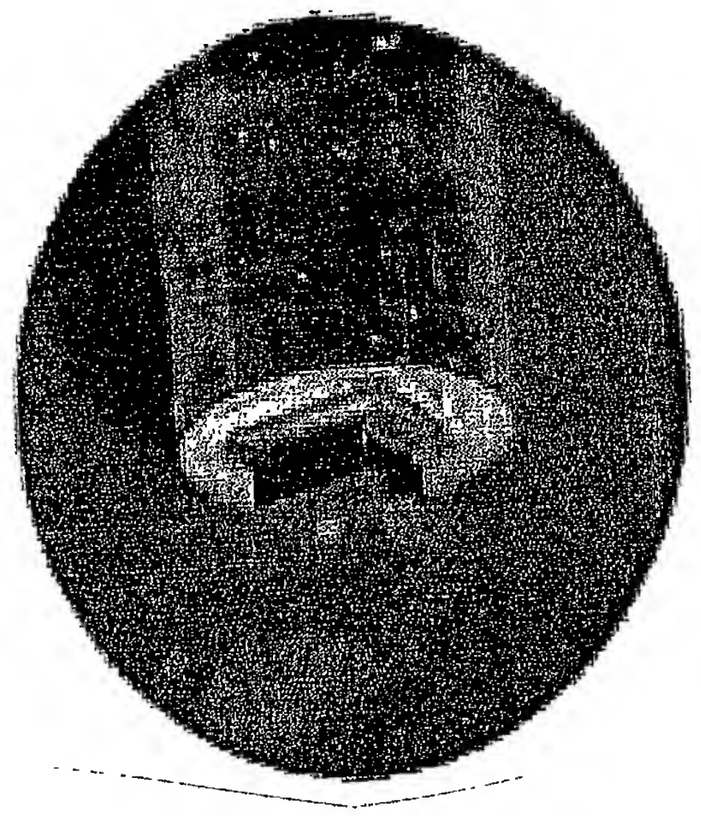


FIG 12

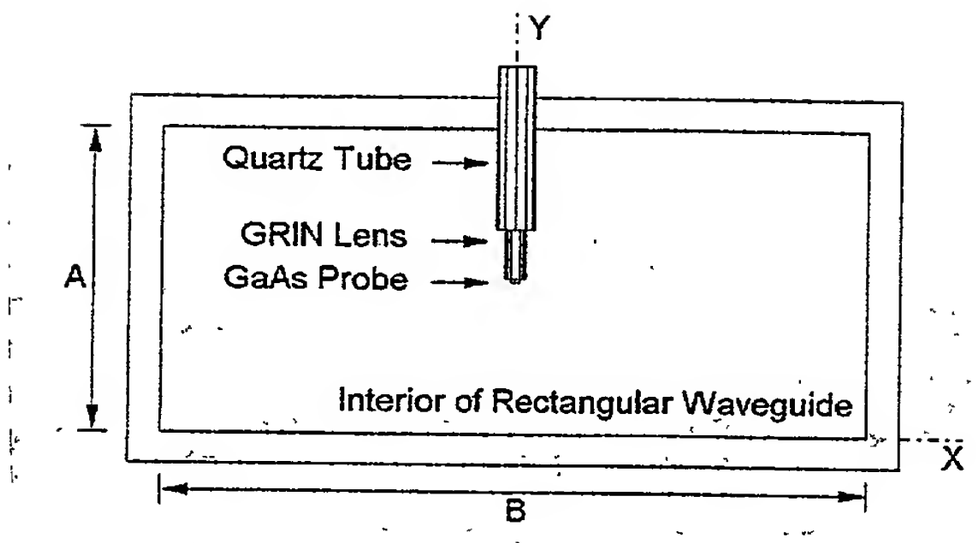

Y
Quartz Tube
GRIN Lens
GaAs Probe
A
Interior of Rectangular Waveguide
X
B

FIG 13

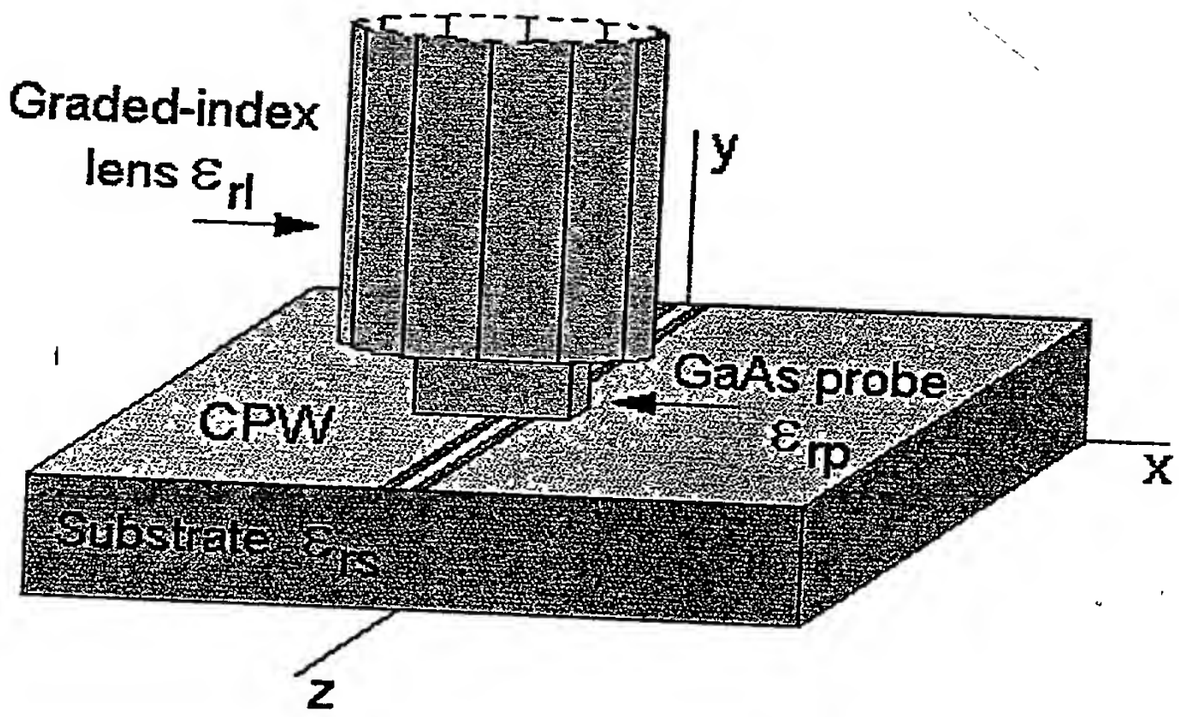
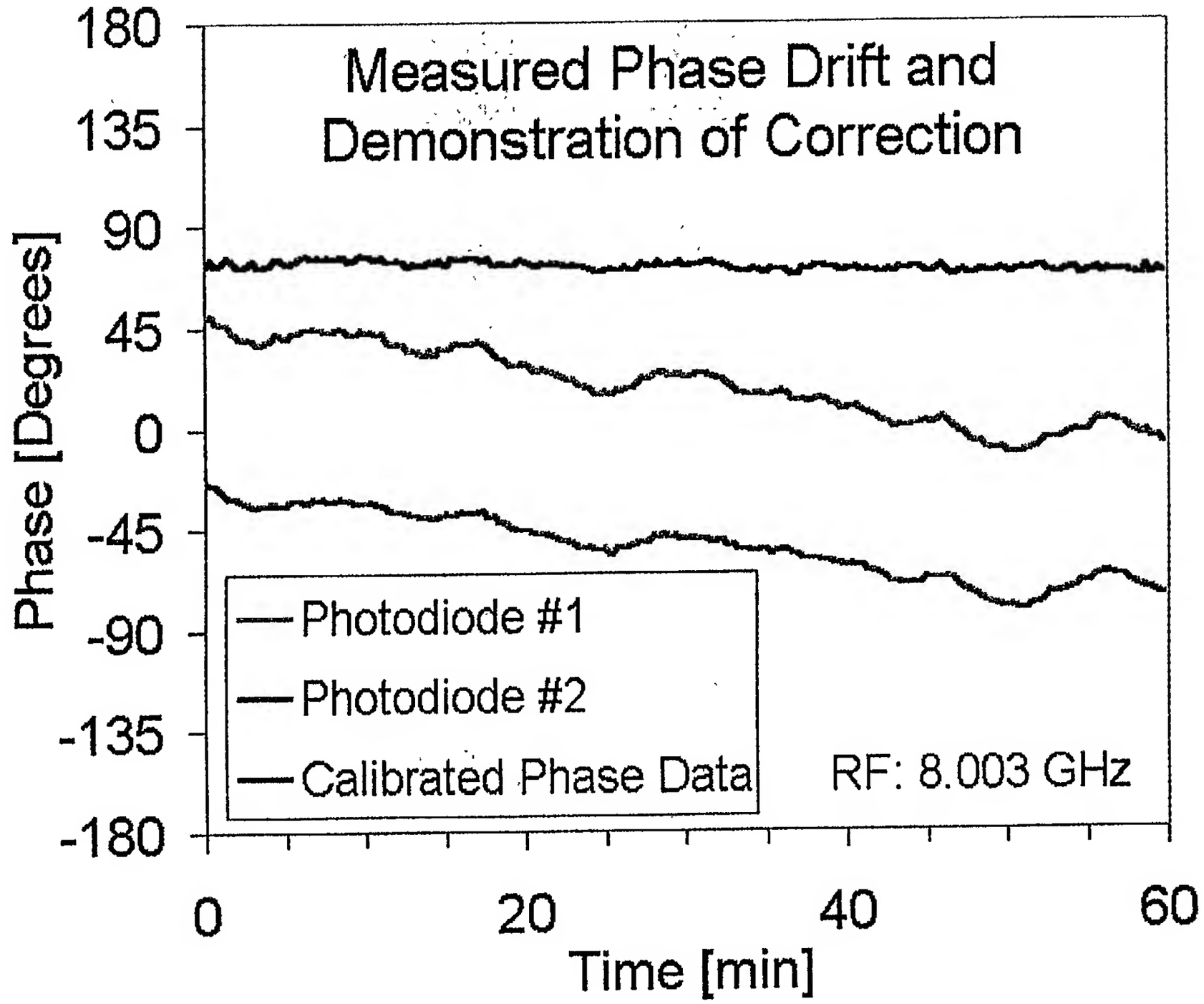

Graded-index
lens ε_{rl}
y
GaAs probe
ε_{rp}
CPW
X
Substrate ε_{rs}
z

FIG 14

Characterization - Electric Field Phase



- Over one hour, measured temporal phase stability is ±3°.

Fig 15

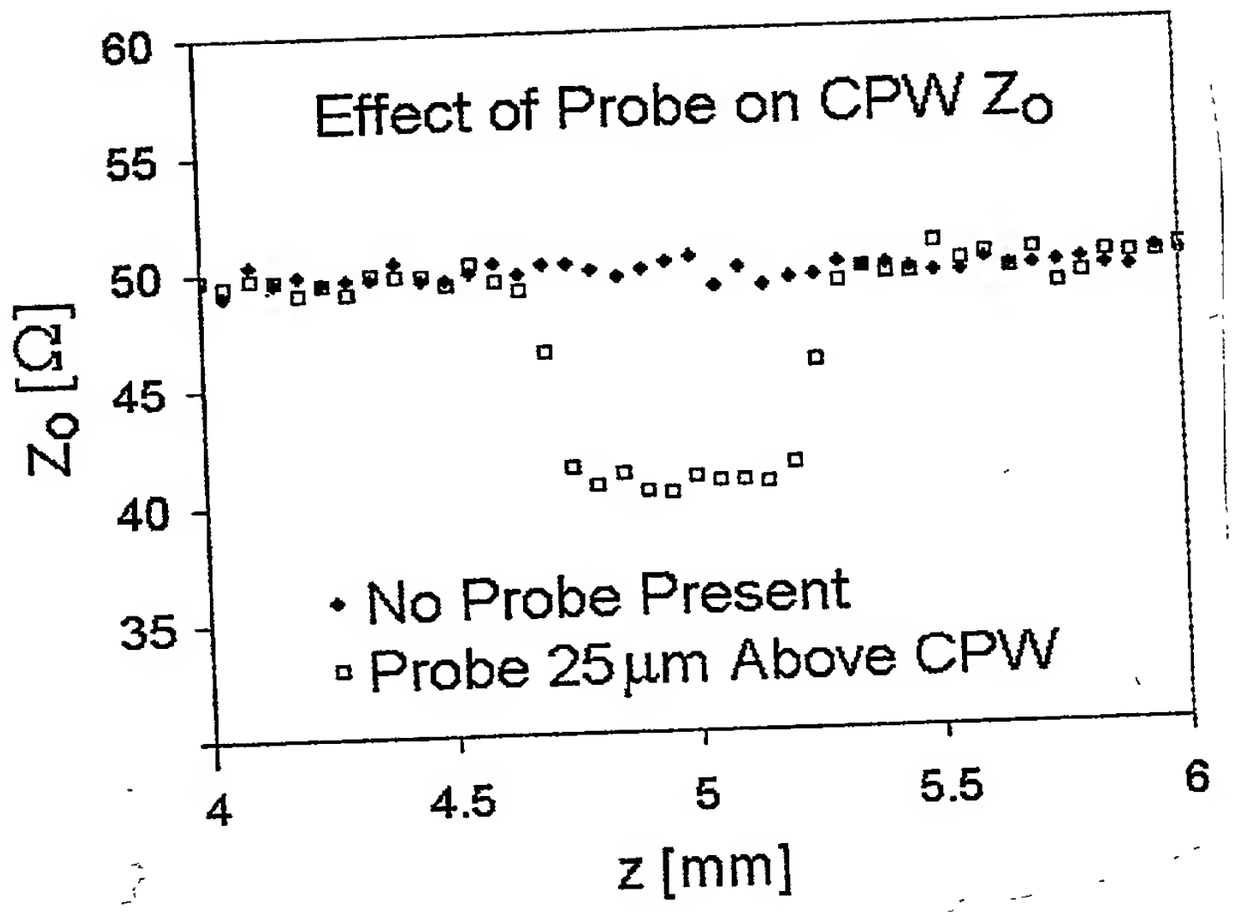
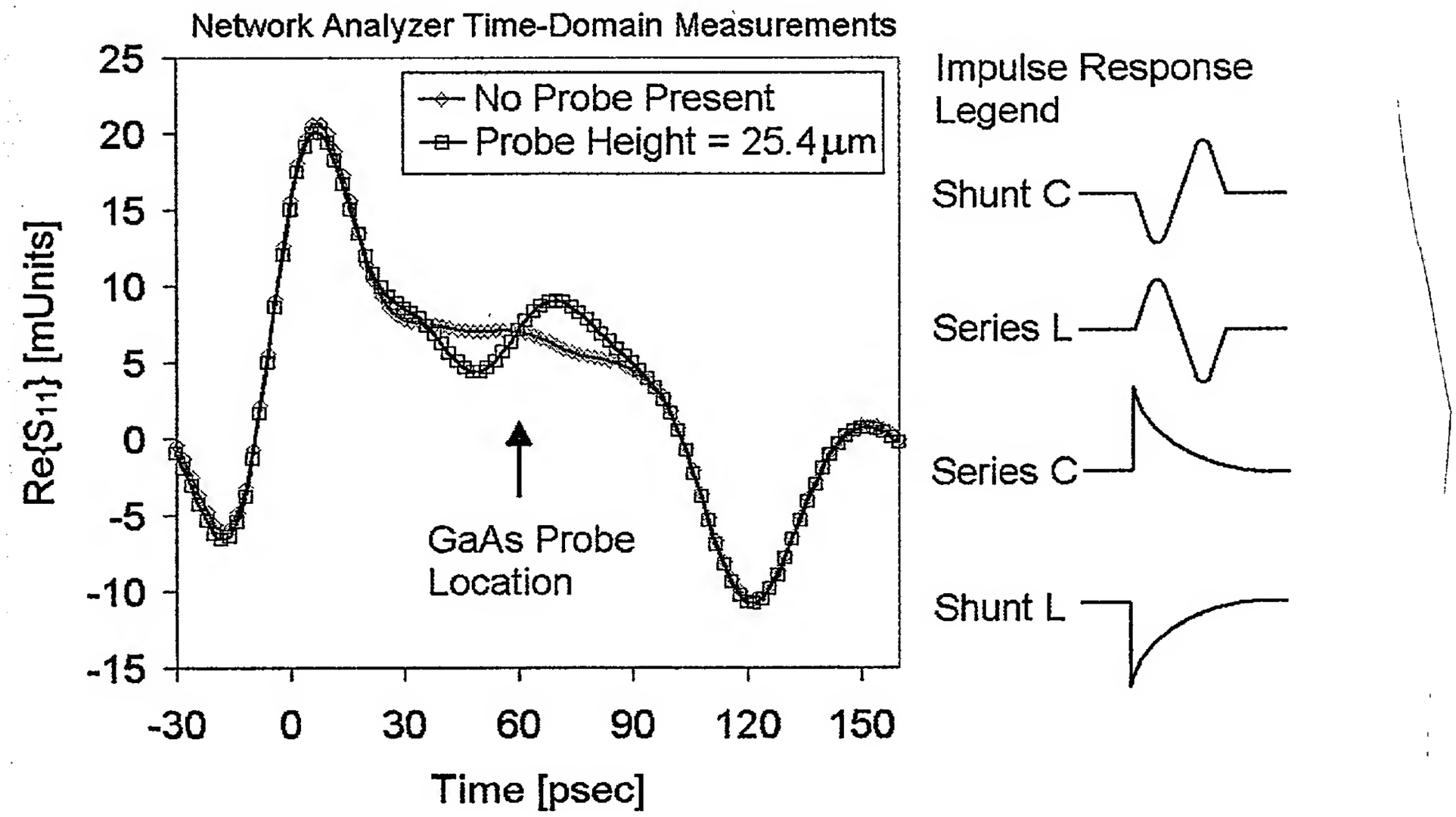
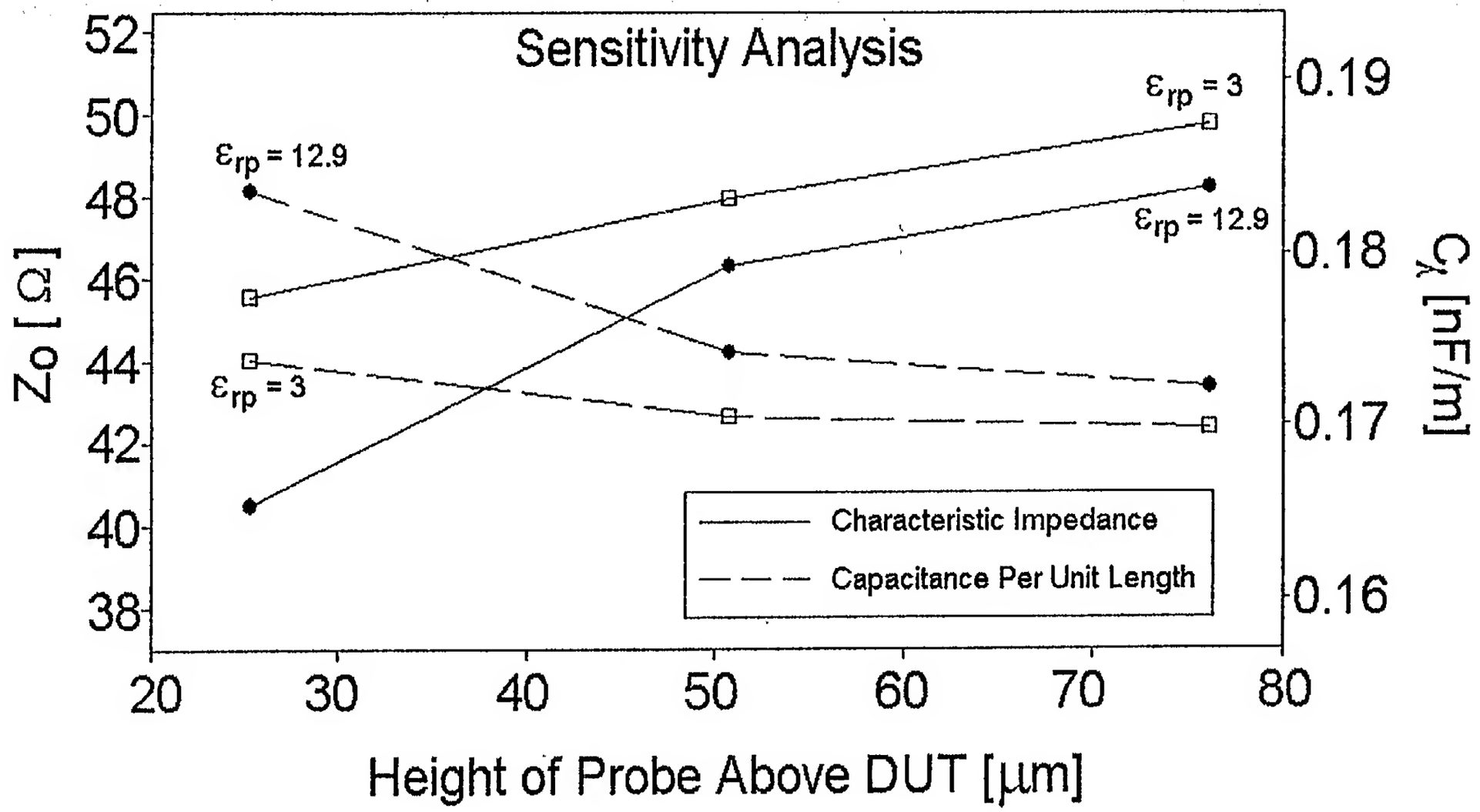


FIG 16



- Frequency domain measurements (2 - 40 GHz): |S11| < -30 dB with and without probe.

FIG 17



- Effect of probe is equivalent to a lumped shunt capacitance on the order of femtofarads.

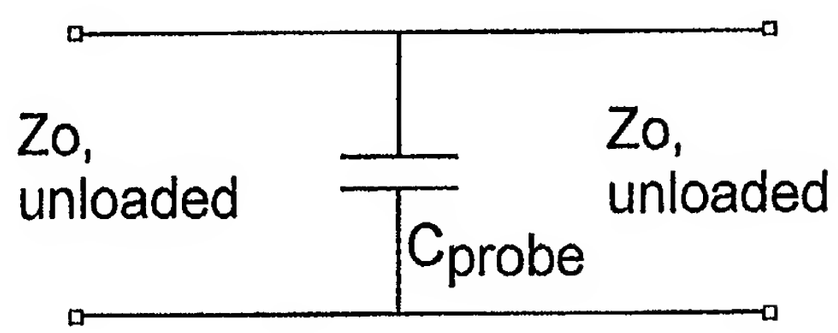


FIG 18

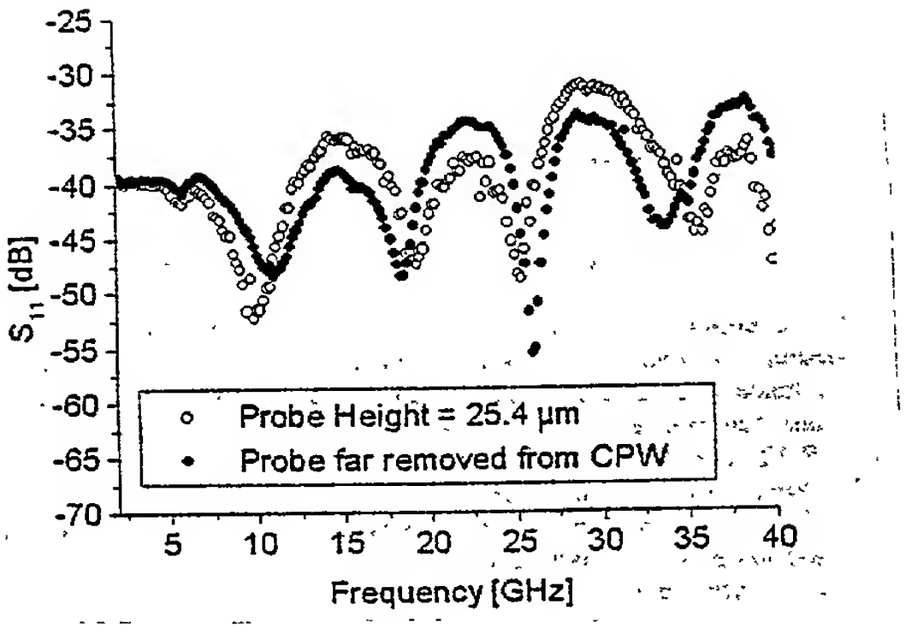

-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
S_{11} [dB]
Probe Height = 25.4 µm
Probe far removed from CPW
5
10
15
20
25
30
35
40
Frequency [GHz]

FIG 19

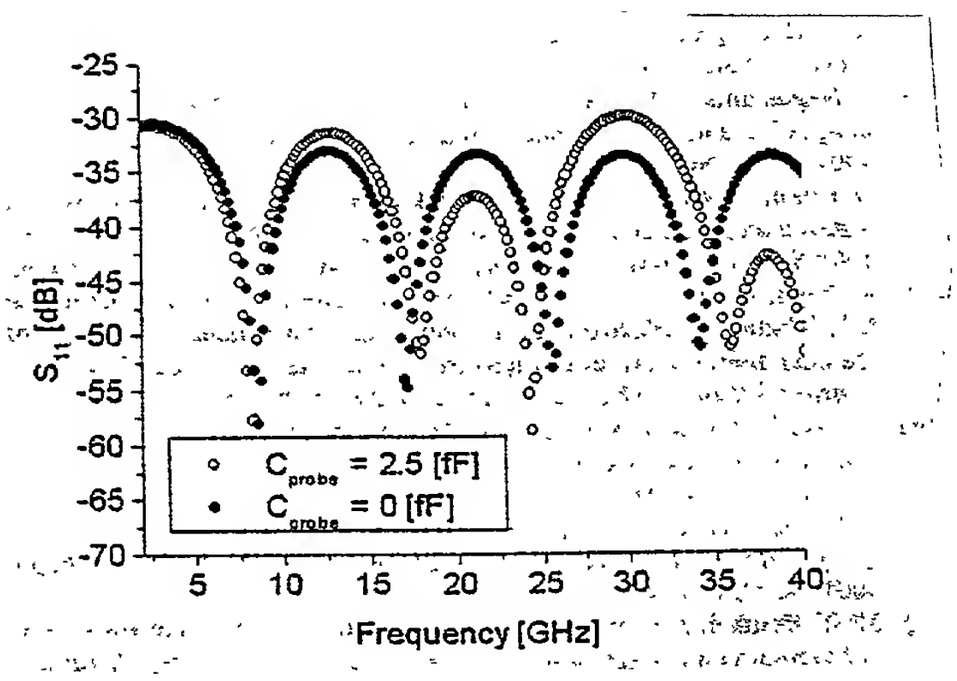

-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
S_{11} [dB]
C_{probe} = 2.5 [fF]
C_{probe} = 0 [fF]
5
10
15
20
25
30
35
40
Frequency [GHz]

FIG 20

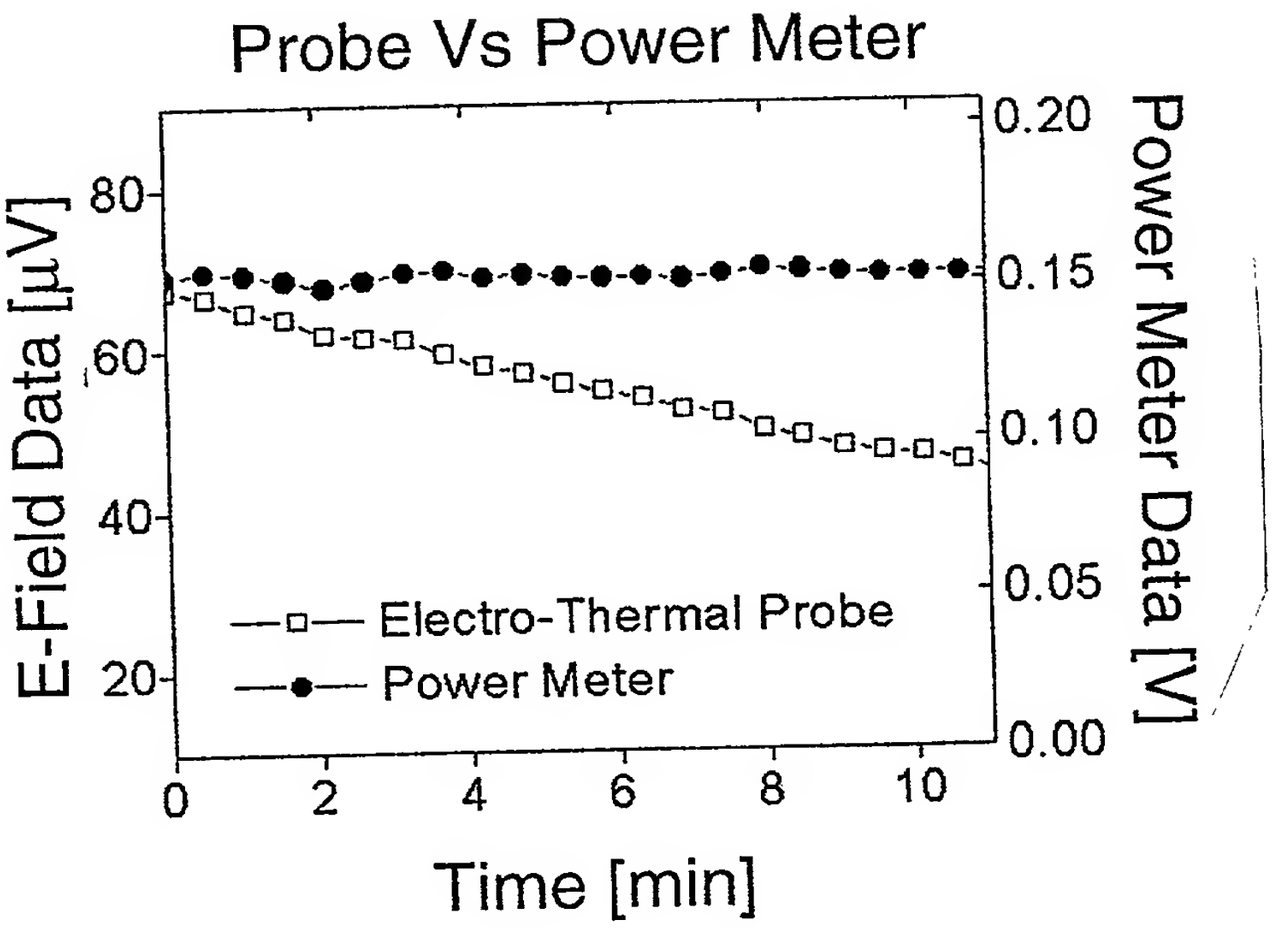

Probe Vs Power Meter
E-Field Data [µV]
Power Meter Data [V]
80
60
40
20
0.20
0.15
0.10
0.05
0.00
0
2
4
6
8
10
Electro-Thermal Probe
Power Meter
Time [min]

FIG 21

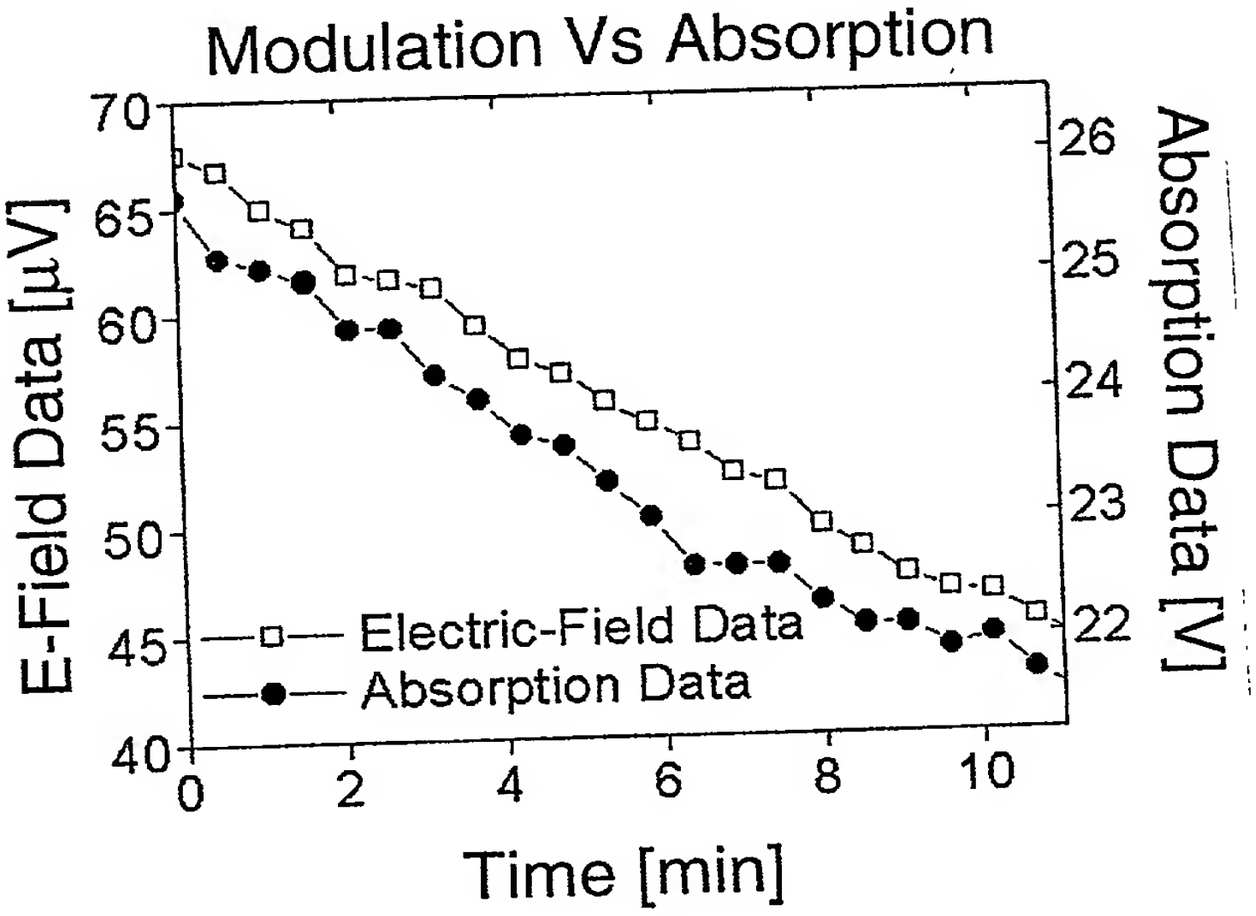

Modulation Vs Absorption
E-Field Data [µV]
Absorption Data [V]
70
65
60
55
50
45
40
26
25
24
23
22
0
2
4
6
8
10
Electric-Field Data
Absorption Data
Time [min]

FIG 22

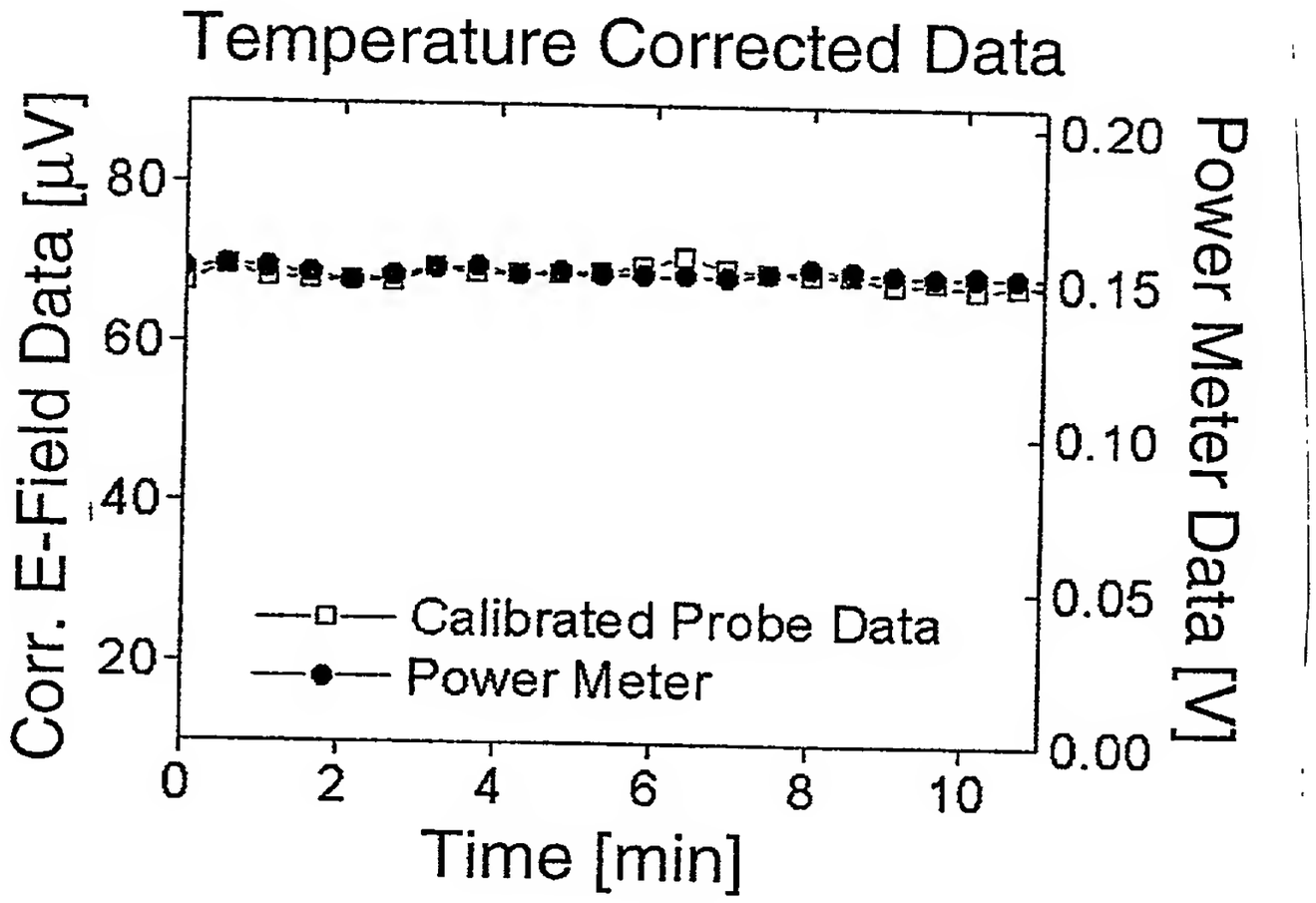

Temperature Corrected Data
Corr. E-Field Data [µV]
Power Meter Data [V]
80
60
40
20
0.20
0.15
0.10
0.05
0.00
Calibrated Probe Data
Power Meter
0
2
4
6
8
10
Time [min]

FIG 23

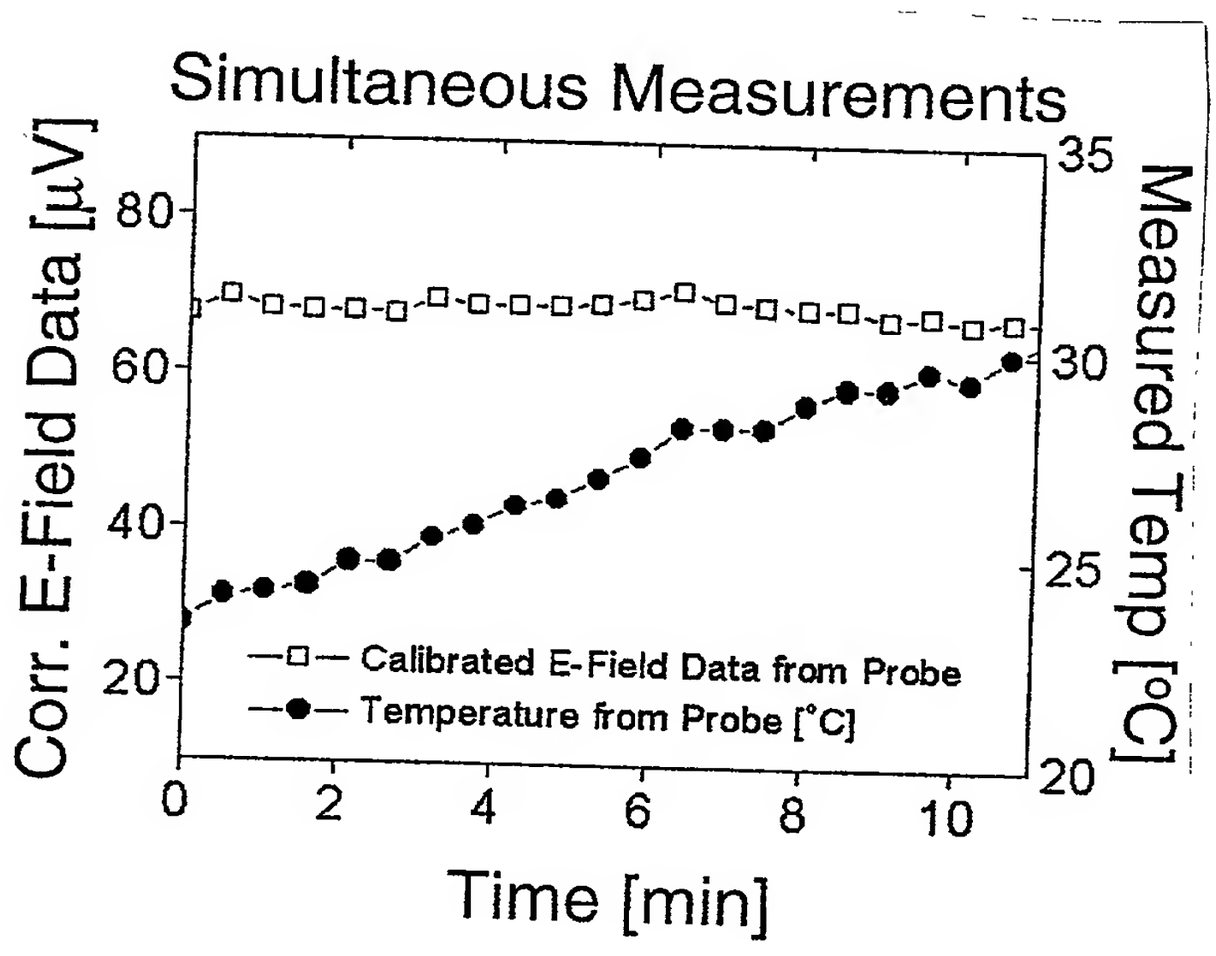

Simultaneous Measurements
Corr. E-Field Data [µV]
Measured Temp [°C]
80
60
40
20
35
30
25
20
Calibrated E-Field Data from Probe
Temperature from Probe [°C]
0
2
4
6
8
10
Time [min]

FIG 24